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Report of J. J. Williams, Chief Engineer, upon the location of the

TEHUANTEPEC RAILWAY

and Carriage Road across the Isthmus of Tehuantepec, with the Map and Profiles as approved by the Government of Mexico, July 1st, 1870,

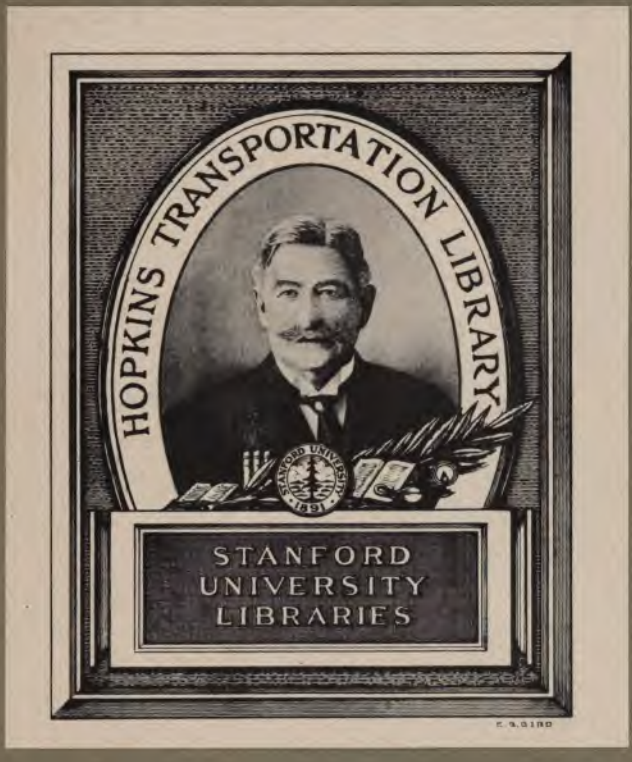
AND

His Report on the subject of a

SHIP CANAL

Across the Isthmus of Tehuantepec, to unite the Atlantic and Pacific Oceans.

1870.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The Tehuantepec Railway Co. would be pleased to have your views upon the subject matter of Col. Williams' Report.

Simon Stevens
President

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Report of J. J. Williams, Chief Engineer, upon the Location of the Tehuantepec Railway and Carriage Road across the Isthmus of Tehuantepec. With the Map and Profiles as approved by the Government of Mexico, July 1st, 1870.

ENGINEER'S OFFICE,
TEHUANTEPEC RAILWAY COMPANY,
174 CHAMBERS ST.

NEW YORK, August 22d, 1870.

SIMON STEVENS, Esq., President.

Sir: In compliance with your instructions, and with maps, plans, profiles and other important documents, I left New York on the 14th of last April for the city of Mexico, where I arrived on the 2d of May. After having made the necessary preliminary arrangements with the Minister of Fomento, I proceeded, to the Isthmus of Tehuantepec, in company with Col. Eduardo Garay, the Engineer and Commissioner representing the Mexican government, for the purpose of establishing the location of the line of the Tehuantepec Railway.

For a better understanding of the subject, I will first give a description of the route:

Leaving Minatitlan, the proposed head of present ship navigation, twenty miles up the Goatzacoalcos River from the Gulf, the line takes the slope of the ridge north of that village and passes just south of Cosuliacaque, thence just south of Tesistepec, following, with but slight variation, and for the purpose of correct alignment, the line of overflow, thence curving to the south and east of Lake Otiapa, thence curving southerly to the eastward of the hacienda of Almagro, thence nearly straight to within one mile west of Mount Encantada, thence curving westwardly and direct to the crossing of the Jaltepec River, about five miles west of Suchil, known as Hargousana. For this division of the road the line is quite direct, the curves of easy radius, and the grades gentle.

The principle governing in this location being to preserve the grade from about three to five feet above the level of extreme overflow and at the foot of the slope of the high land which constitutes the dividing ridge between the waters of the San Juan and Goatzacoalcos Rivers, and following this line, to preserve the shortest practicable route, to the crossing of the Jaltepec. At Hargousana the Jaltepec is crossed

at the level of one hundred and ten feet above high tide, at Ventosa. The line from thence south follows a depression in the ridge and rises for one and one-half miles at the rate of sixty feet to the mile to the summit, which divides the waters of the Jaltepec from those of the Jumuapa River. This summit is just south of the Picadura to Suchil, and is two hundred and ninety feet above high tide at Ventosa.* The line thence running southerly descends for eight miles, crossing several branches of the Jumuapa until it reaches the latter at Paso de la Puerta, with no grade exceeding sixty feet to the mile. Crossing the river at this place at a height of one hundred and fifty-five feet above tide, the line then follows a branch of the Jumuapa, which lies in the direction of the route to the summit between the valleys of the Jumuapa and the Sarabia, a distance of six miles, two miles of which is at the rate of sixty feet to the mile, with a total rise in that distance of one hundred and ninety-five feet. From this summit the line continues direct to the Sarabia River, a distance of four miles, over a gently undulating profile, and crossing the latter river at a height above tide of three hundred and five feet, or a fall of but forty-seven feet in four miles, curves to the eastward and following a branch of the Sarabia for two miles, with a rise of twenty feet per mile, reaches the summit between the Sarabia and the Malatengo Rivers, at a height above tide of three hundred and forty feet, thence following a tributary of the Malatengo over a gently descending grade, (Arroyo de los Venados, about two miles south of Boca del Monte), it crosses the latter river about two hundred and eighty feet above tide, and near its junction with the Rio Almaloyo, and skirting the base of the upland between the two rivers, takes the valley of the Rio Almaloyo, which it follows to the plains of Chivela, a distance of twenty-four miles, rising in that distance four hundred and ten feet, or a mean rise of seventeen feet per mile, with no grade of over fifty feet per mile. Still following a branch of the Almaloyo, it crosses the Chivela plains and enters the Pass of Chivela at a height of seven hundred and seventy-three feet above tide, or a rise of eighty-three feet in four and one-half miles. This is the extreme height of the grade at the summit pass which divides the waters which flow into the Pacific from those which flow into the Atlantic. From the summit of the Pass of Chivela for a distance of three and one-half miles the line descends a tributary of the Rio Verde on a grade of one hundred and sixteen feet per mile to the crossing of the Guichilona, thence by the valley of the Rio Verde three and one-half miles, on grades not exceeding fifty-three feet per mile, to Rancho de la Martar, at the base of the mountains on the Pacific plains. This point is two hundred and forty feet above high tide at Ventosa. The total distance from Minatitlan to Salina Cruz by this location is one hundred sixty-two and one-half miles, which is composed of sixty-two miles on the Atlantic plains, sixty-six miles through the mountain division, and thirty-four miles over the plains of the Pacific.

The maximum grade is sixty-three feet per mile excepting the grade through Chivela pass, which, ascending toward the Gulf, is 116 feet per mile, but only for a distance of three and one-half miles, and in operating the road a pushing engine will be required to be used in assisting heavy northern bound trains over the summit. This should not be considered a very unfavorable feature in the route from the fact that on one of the greatest thoroughfares in the United States—the Baltimore and Ohio—the same grade was adopted in crossing the Alleghanies for a distance of sixteen miles.

The maximum curvature is 7° or a radius of 819 feet, and this is only used in the pass of Chivela.

In estimating the cost of the Tehuantepec Railway, I have before me the report of General Barnard containing my original estimates, and also the reports of the Chiefs of parties under General Sidell.

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* When reference is made to high tide, it means high tide at Ventosa.

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With these I am able to make you the following approximate estimate of the cost of construction.

Auxiliary and carriage road between Minatitlan and the Jaltepec River	$62,000 00
Auxiliary road from the Jaltepec to Salina Cruz	41,000 00
Clearing, grubbing, graduation, masonry, and bridging —Minatitlan to the Jaltepec	1,200,000 00
Do. do Jaltepec to Salina Cruz	4,120,000 00
Superstructure—Minatitlan to Salina Cruz	1,271,922 28
Stations, buildings, and water fixtures	216,000 00
Engines and cars	332,150 00
Engineering and contingences, 10 per cent	720,000 00
Total cost	$7,963,072 28

Or say in round numbers $8,000,000.

This is the maximum cost, but during the construction of the road, in working up the location, and in the modification of the grades, tangents and curves, for the minimum expenditure, it may be considerably reduced.

Article No. 23 of the general regulations governing the construction of all railroads in the Republic of Mexico, gives the Company the right to make such changes in the line of location as they may deem proper and useful. It is very seldom that a railroad is constructed without some modification of the original location.

In the examintion and location of the line as above described, Col. Garay, the Commissioner representing the Mexican Government, expressed his surprise at finding so favorable and practicable a route, particularly in going through the Pass of Chivela, by far the most difficult portion of the whole line. He said the engineering difficulties there are not one-tenth part as formidable as those in the passes through the *Chiquihuites* and *Cambres* Mountains on the "Vera Cruz and City of Mexico Railroad," of which he is also the Government Inspector.

CARRIAGE-ROAD FROM MINATITLAN—THE PRESENT HEAD OF SHIP NAVIGATION ON THE GULF—TO SALINA CRUZ.

The wagon or carriage road, which it is in contemplation to complete previous to the construction of the railroad, will serve not only as an auxilary to the latter, but as a means of developing the resources of the Isthmus; and the Company will as much as possible avail itself of the expenditures which have already been made for that purpose. The location will be as follows:—

From Minatitlan to Cosuliacaque, thence to Sayula, thence passing 1½ miles west of the hacienda of Almagro to Pavious Monteria, thence to Hargousana on the south side of the Jaltepec river, thence to Tortugas, thence to Sarabia, thence to Antigua Hacienda, thence to the Almaloyo and Otate, thence to Chivela, thence to the Rio Verde, thence to San Goronimo, thence to the city of Tehuantepec, thence to Salina Cruz, a total distance of 210 miles.

The road bed to be cleared and ditched where necessary; culverts to be built at the stream-crossings;—the Jaltepec, Tortugas, Puerta, Sarabia, Malatengo, Arroyo de Xochiapa, Almaloyo, Torrenta de Guichilona, Rio de los Perros and Tehuantepec rivers to be bridged with substantial timber truss bridges on pile bent or stone abutments, and piers. The timber to be cleared for a width of 50 feet, and the road bed to be properly graded for wheel travel for a width of at least 15 feet. The best assurance of the proper character of this portion of the work will rest in the fact, that the economy with which the railroad construction will progress will be largely dependent upon the efficiency of this road, and its ability to sustain the heavy traffic of material and supplies which will seek it at all times. It will be perceived that the railroad takes the valley of the Almaloyo, while the carriage road

passes over the plains of Xochiapa, and through Nisi Conejo pass distant from the railroad-line some five miles. It may therefore be found advisable on further examination, and in order to facilitate the operations of constructing the railroad, to change the route of the carriage road from the plains of Xochiapa to the valley of the Almaloyo. As a preparatory step toward the commencement of the works in November next, we made a pretty thorough examination as to the condition of the wagon or carriage road, from Suchil to the head of shoal water navigation on the Goatzacoalcos (95½ miles above Minatitlan), to Salina Cruz. We found it a good deal chocked up with under-growth and fallen trees, more especially between Paso de la Puerta and Suchil, where for the middle portion of this distance we could not make our way through it on horseback.

Some considerable grading will be necessary at various places along the route, and particularly in repairing washes over the Xochiapa hills, and through the Chivela pass.

I have estimated an amount not to exceed $41,000, which will be amply sufficient to place it in fair running order.

Having completed our labors on the Isthmus in the inspection and location of the railway and carriage road, the Mexican Commissioner returned with me to the city of Mexico, where he wrote to the Minister of Interior, recommending the location of the railway and carriage road to the approbation of his Government.

I also wrote the Minister of Interior the following letter:

"Mexico, June 28th, 1870.

Sr. D. Blas Balcarcel, Ministro de Fomento.

Sir: In the name of the Tehuantepec Railway Company, I have the honor to present to you the following maps, plans, and profiles, made from the surveys of Generals Barnard and Sidell, showing the location adopted by the Company, of its proposed railway and carriage road.

1st. A large and complete topographical map of the Isthmus of Tehuantepec, showing the line of location of the railway and carriage road, as adopted by the Tehuantepec Railway Company, with a profile of said location on the same map.

2d. A profile from Minatitlan over the Atlantic Plains to the Jaltepec River.

3d. A profile from the Jaltepec River over the middle division to Rancho de la Martar, at the base of the mountains on the Pacific Plains.

4th. Profile from Rancho de la Martar over the Pacific Plains to Salina Cruz.

5th. A certified copy of the original topographical map of the Barnard and Sidell surveys, from Minatitlan to Salina Cruz, now in possession of the Company, showing the line of location of the proposed railway and carriage-road.

The whole made pursuant to the 5th, 6th, and 7th articles of the concession of Jauuary 2d, 1869. I, therefore, respectfully solicit your approbation of the same.

I have the honor to be,

Very respectfully, your ob't serv't,

J. J. Williams,
Chief Engineer Tehuantepec Railway Co.

These maps, plans, and profiles, accompanied with a complimentary letter bearing the approbation of the Mexican Government, and showing the hearty co-operation of the Minister of Interior, were returned to me, in the city of Mexico, on the 4th of July, 1870. The next morning I left for New York, where I arrived on the 21st, and on the 22d of July, delivered them all to you, at this office, having successfully accomplished the principal object of my mission.

I desire to mention that much of the success, which attended me

on my recent expedition to Tehuantepec, is due to Col. Eduardo Garay, the Mexican Commissioner.

As your instructions directed me to obtain as much additional information as possible, bearing on the subject of the railway across the Isthmus, I take occasion to say that, notwithstanding all that has been said and written about Tehuantepec, I do not think that the Isthmus has yet been fully described.

In the first place a map should be made upon which can be laid down the coast and lateral railway lines which may be built to act as feeders to the main trunk line, across Tehuantepec; and in order to do this the plan should include on the west as much of the States of Vera Cruz and Oaxaca as will take in the cities of the same names; on the east, the States of Tobasco, Chiapas, and a portion of Guatemala bordering on the Pacific; upon such a map should be projected the following connecting or branch lines:

First, a road should start at or in the neighborhood of Soledad, a station on the Vera Cruz and city of Mexico railroad, about twenty miles from the former city, and run down to the lagoons connecting with the harbor of Alvarado. This piece of road, which might be a branch of the Vera Cruz and city of Mexico railway, would be about thirty miles long, and, as I am informed, almost on a dead level the whole distance.

The next should commence at or near San Nicholas, a hacienda on the San Juan River, at the head of steamboat navigation, about forty miles by water above the beautiful city of Tlacotalpan, thence by the valley of the same river fifty miles to the town of Paso San Juan, thence by the same valley, as far as it goes in the proper direction, thirty-five miles to Hargousana, on the Jaltepec River, there joining the Tehuantepec Railway. This line would be composed of eighty-five miles of railway and about seventy miles of inland navigation, and pass by the very doors of the cities of Alvarado and Tlacotalpan, and without the necessity of going on the Gulf at all. A good line may also be continued from the Valley of the San Juan over an easy profile to Minatitlan, thus connecting the whole of the interior Atlantic slope of Mexico with its rich possessions on the Pacific coast, by way of the proposed railway (acting as a funnel) across the Isthmus of Tehuantepec, and, without exaggeration, passing through one of the most productive regions in the world. To give you an idea of a portion of this route, I will mention that Col. Garay, the Mexican Commissioner, and myself, when on our way down the San Juan River in a canoe, estimated about 100,000 head of splendid cattle in this valley; but on our arrival at Tlacotalpan, Mr. Schleskie, one of the oldest, wealthiest, and most respectable inhabitants at that place, informed us that we were entirely below the mark, as there were at least 500,000 head in that and its connecting valleys. In the construction of the road this will be an important item.

The second branch railway should start from Rancho de la Martar, or from the point where the trunk line will enter the mountains from the Pacific plains, and run easterly down the coast, over nearly level ground, to the harbor of Tonala, and continue through that part of the State of Chiapas bordering on the Pacific, to the frontier of Guatemala.

Such a line as this would put the Tehuantepec Railway in direct communication with one of the richest and most beautiful countries in the world. I am informed by intelligent gentlemen on the Isthmus, who live in Chiapas, that that State alone produces on the Pacific coast annually about 5,000 bales of indigo, 5,000 bales of tobacco, 50,000 arobas of sugar, 5,000 bales cacao, 15,000 bales india-rubber, 6,000 bales cotton, 6,000 sacks coffee, 50,000 hides, to say nothing of the corn, ginger, vanilla, sarsaparilla, and the immense amount of Brazil wood and other valuable products, all of which will be sent to market over the Tehuantepec Railway. And then, too, the entire population

and products of the Pacific slope, for some two hundred miles east and west of the Isthmus, would find the same outlet to market; and when the Vera Cruz and City of Mexico Railway is completed, would be placed in direct and easy communication with the Capitol and the whole interior of the Republic.

The third lateral railway should start on the Pacific coast in the State of Oaxaca, at or near the outlet of the valley in which is situated the city of the same name, and run down to the harbor of Huatulco, thence to Salina Cruz, to connect with the Tehuantepec Railway.

This would place the whole silver mining regions of the State of Oaxaca, as well as the city itself, in easy communication with the Gulf, coast, and the city of Mexico by way of the Isthmus of Tehuantepec.

The great advantages of the proposed tributary roads are their extreme feasibility and the comparative ease and cheapness with which they can be constructed, the ground over which they would pass, for the greater portion of the distance, being nearly all level plains.

The above, together with what has been said by General Barnard, in his report, pages 139 to 142, ought to convince the most sceptical that the *local business alone* would make the Tehuantepec Railway a paying investment, to say nothing of the through traffic, from which a very large income may be expected with reasonable certainty.

I have the honor to be,

Very respectfully,

J. J. WILLIAMS,

Chief Engineer Tehuantepec Railway Co.

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Report of J. J. Williams, Chief Engineer of the Tehuantepec Railway, on the Subject of a Ship Canal across the Isthmus of Tehuantepec.

ENGINEER'S OFFICE,

Tehuantepec Railway Company,

174 CHAMBERS STREET.

New York, September 10, 1870.

SIMON STEVENS, ESQ., *President.*

SIR: Pursuant to your instructions, I proceeded to the Isthmus of Tehuantepec, in company with Col. Eduardo Garay, the Mexican Commissioner, for the purpose of establishing the location of the line of the Tehuantepec Railway. Those instructions directed me also to obtain as much additional information as time would permit regarding the feasibility of a Ship Canal. I herewith submit my report, and beg to mention that I have ascertained facts, which, in my opinion, ought definitely to settle the question of its proper location. I consider Tehuantepec the proper place for an interoceanic Ship Canal, for the following reasons:

First. No tunnel will be required on the entire route.

Second. It will require no very deep cuttings. The summit reach of the Canal may be about five miles long, through a nearly level plain, with a depth of cutting but little more than sufficient to contain the water to pass the ships.

Third. There is a large extent of contiguous territory with an elevation above the summit, which, it is believed, contains streams that will afford water sufficient to supply the summit level.

According to Moro's survey, the natural surface of the ground at the summit of Tarifa is 684 feet above the sea. The town of Tarifa, 5 miles north of this, is somewhat elevated, in the midst of ground so level that in the rainy season it becomes inundated, for which reason this plain has been called the Lake of Tarifa. Señor Moro took advantage of this circumstance to save the trouble of a new line of levels between the latter place and the pass of the same name, since the line indicated by the waters subsiding clearly showed that the two points were nearly on the same level. Consequently, it is ascertained that, with a cut of a few feet at the summit of the pass, the waters to the south of the town of Tarifa would flow toward the Pacific, whilst those on the north side naturally run over gently descending ground, as far as the Goatzacoalcos, on their way to the Gulf.

The Railway, as located, crosses the Almaloya River six miles north of Chivela, which point is on the same level with the summit of Tarifa—hence it has been suggested that the waters of the Almaloya,

and of the other streams to the west of Tarifa, might be brought by trenches to the summit level of the canal.

The feasibility of obtaining a supply of water from these sources involves only a question of cost to be compared with the cost of bringing water from the Chicapa and Ostuta on the east of Tarifa.

There is scarcely a doubt that, from these combined sources, a sufficient quantity of water can be obtained to supply a ship canal, estimating its highest probable requirements. Possibly either source would give sufficient.

The streams on the east of Tarifa, from which it is proposed to bring the water by means of feeders, to the summit level, are the Chicapa and Ostuta. On the former, at a place called "*Ultimo Rancho*," the elevation is also on the same level with the summit at Tarifa. A short distance higher up, the river forms a cascade of about 23 feet. In making the surveys to solve the problem of the water supply for the summit, it will be advisable first to make an accurate survey for a base line of operations to which all lines for feeders should be referred. For this purpose I would run a transit line from the mouth of the Chicapa, where it enters the upper lagoon, following up the west bank of that river to the west of "*La Venta de Chicapa*," thence to the "*Rancho de Agua escondido*," thence to the summit of Tarifa, thence across the plains to the town of Tarifa, thence down the valley of Tarifa River to its junction with the Chichihua, thence to the Malatengo, on a total distance of 50 miles—the estimated length of the artificial canal. Over this line I would run very accurate levels, at intervals of 100 feet, taking high tide as a reference plain. Such a line as this would show the exact height of the ground above high tide in the lagoons for every 100 feet, for the whole distance from the mouth of the Chicapa over the summit, down the Tarifa and Chichihua rivers to the Malatengo. Such a line would form an excellent base of operations, and would probably demonstrate the practicability, by deepening the summit cut, of bringing the whole volume of the waters of the Chichihua to the summit level of the canal; in which case the summit reach might possibly be made as much as eight miles long, and thus avoid the necessity of bringing feeders from the Chicapa, Ostuta, Citune, or Almaloya rivers.

Lateral transit and level lines should be run from Tarifa through the pass of Convento to "*Ultimo Rancho*," or to a point on that river high enough to allow its waters to flow through a trench to the summit at Tarifa. Eye and instrumental examinations should then be made to ascertain the practicability of uniting the waters of the Ostuta with those of the Chicapa, in order that the two volumes might, if required, be poured into the summit level of the canal. Transit and level lines should also be run from Tarifa, by way of "San Tiago" and the Chivela Plains to the railway crossing of the Almaloya, for the purpose of accurately testing its elevation, as determined by former surveys, and the practicability of running a feeder from this point through the "Timbon" range east of the Almaloya to the plains of Tarifa, and thence to the summit level of the canal. It will thus be seen that there are no less than four principal rivers, the waters of which, in the absence of instrumental surveys, it is reasonable to calculate, may be brought, if necessary, to the summit.

As Principal Engineer of the Commission under General Barnard, while making explorations and a survey for a railroad across the Isthmus in 1851, I took occasion to examine the dividing ridge over which Moro had made his surveys for a ship canal in 1843; and although I did not pass over the entire route as surveyed by Moro for a ship canal, still I was at Tarifa, the summit, and on the most difficult ground over which he proposed to construct it, and I think I am safe in pronouncing the route, as surveyed by him, the most practicable of any yet explored, and it is very doubtful if any other will be found

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with like good harbors at each terminus, that can be built for less money, or be of more general benefit to the world, notwithstanding the often quoted opinion of Rear Admiral Charles H. Davis, as expressed in his late able literary report to Congress on the subject of Interoceanic Canals.

As the only objection that can be made against the Tehuantepec canal is the number of its locks (estimated to be from 60 to 68 on each side of the summit, depending upon the depth it may be thought necessary to excavate the summit cut), I will mention here that each lock of the Caledonia Ship Canal cost upon an average, 40,000 dollars. This amount, by 136 the greatest number estimated as required on Tehuantepec, would give a cost of 5,340,000 dollars. The cost of the Caledonia Canal, exclusive of the locks, was $152,000 per mile. This amount by 173—50 miles of canal proper and 123 of slack water navigation, both estimated at the same rate per mile to be on the safe side —would give $26,296,000 dollars, and with the cost of the locks included, $31,636,000 as the total cost of a ship canal across Tehuantepec. This is estimated precisely on the basis of the Caledonia Ship Canal. See statement in the Encyclopedia Britannica, 7th edition, vol. 19, page 750.

To show that the number of locks required on Tehuantepec is very far from being an insurmountable obstacle in the way of the construction of the canal, I append to this report a table marked "A" showing the length, height of lockage, and number of locks on some of the principal canals in the world. In view of this I would ask any civil engineer, however able and practical he might be, supposing the canals mentioned in the table to have been built with an amount of lift varying from 188 to 3,129 feet, and with locks numbering from 28 to 398, if he can reason himself into the belief of the impracticability of the Tehuantepec Ship Canal, provided, of course, that there is sufficient water at the summit.

Suppose we take for example, the Chesapeake and Ohio Canal, with its 398 locks and its height of lockage of 3,129 feet, who will say, with the before-mentioned advantages in view, that a canal across Tehuantepec, with one-third the height of lockage and less than one-third the number of locks (provided, of course, there is no lack of means), cannot be constructed of twice its width and three or four times its depth, or sufficiently large to pass ordinary ships.

It may be necessary, to provide against a scarcity of water in the dry season, to construct storage reservoirs and double transit locks on each side of the summit level, as far down as the feeders furnish a supply. But it has occurred to me, that in the event of the government surveys finding an abundance of water for the summit level. that the advantages of making all the locks *double transit* might be worthy of consideration. It would probably enhance the cost over the single lock system about 60 per cent. The side walls would be nearly the same for a double as for a single lock, and the increase in cost would mainly consist in foundation and in the construction of a middle pier or partition-wall dividing the lock into two chambers. Some of the advantages of a double over a single lock canal would be:

1st. It would materially shorten the time of the passage of vessels from one ocean to the other, for the reason that they would not be required to wait for each other at the locks, thus greatly increasing the business capacity of the canal.

2d. In a single lock canal the whole of the lockage water used passes off at once into the lower reaches with its attendant abrasive action, whereas, in a double lock, in some cases, only one-half of it would be used in raising ascending ships.

3d. It would be a double security against the detention of vessels on account of locks getting out of order, for the reason that if the use of one was suspended for repairs, the opposite one could be used.

4th. The additional facilities, over a single lock, which it would offer to the present commerce of the world, in the speedy and sure

transit of ships, would induce an increase of trade between the two oceans which it would be difficult to estimate.. Commercial traffic increases directly in proportion to the increase of facilities offered in transportation and in the inverse ratio of the time of transit.

It should be borne in mind, in considering double transit locks, that it will not be required to make the excavations for the canal any larger than for the single lock system, as the *reaches* on the latter are necessarily made sufficiently wide for ships to meet and pass each other. In other words, the increase of cost will mainly consist in making a single into a double lock, by means of a division wall, dividing the locks into two chambers, thus giving the canal advantages analogous to a double track railroad.

Such work as this should be carried out on a scale commensurate with the magnitude of the enterprise, the wants of commerce and the advancement of modern engineering science.

The next point which claims attention is *harbors* and the capacity of the rivers for ship navigation.

First, with regard to the Goatzacoalcos. The fact of there being no delta at the mouth of the river, and the constancy of the depth upon the bar, (from 12 to 16 feet, depending upon the winds and tides), which has remained unchanged, according to the history of the country, for nearly three centuries, proves that it has attained its *regimen*, and indicates that any improvement, by deepening the channel to 18 or 20 feet, may be relied on as permanent. This being done, large vessels could, with some inexpensive improvements of the upper part of the channel, ascend the river 34 miles. I have seen ships opposite Minatitlan, 20 miles up the river, loading mahogany, from rafts alongside.

The Uspanapa, also a large river, empties into the Goatzacoalcos, some sixteen miles above the Gulf, and is navigable for vessels for some 20 miles or more above its mouth. It may, therefore, be said that we have, now, on the gulf side of the Isthmus of Tehuantepec, at the terminus of the proposed railway and ship canal, two rivers, the united lengths of which will form a harbor of over 50 miles in extent, sufficient, to say the least, to accommodate a very large number of ships, if not enough for the whole commerce of the world.

As to the harbors on the Pacific, the lagoons can be made into one of the best in the world. Boca Barra, the outlet of the lower lagoon to the sea, can be deepened to the required depth by dredging and by utilizing the outward currents, and a channel dredged through them, where the depth of water is not sufficient, to the southern terminus of the railway and canal, on the north side of the upper lagoon, or a channel, some two and a half miles long, may be cut and dredged across Tilema to the upper lagoon, at some point between Boca Barra and Huaxontlan del Mar.

A few of the large steam dredges, such as were used on the Suez Canal, would easily do the work. In other words, if Mons. Lesseps can excavate and dredge his canal some fifty miles through the lagoons and sands of Arabia, we ought, certainly, to find no difficulty in deepening the lagoons of Tehuantepec.

The route of the canal to connect the Atlantic and Pacific harbors would commence on the gulf side at the foot of the island of Tacamichapa, the head of present ship navigation, 34 miles from the Gulf, and follow the meanderings of the river by means of locks and dams, or slack water navigation, 123 miles—about 60 by an air line, upon which it may yet be thought advisable to make an artificial canal—to the mouth of the Malatengo. The fall of the river on this distance is 130 feet, or a little more than one foot to the mile, mostly above the Sarabia, requiring only 13 locks. From the mouth of the Malatengo, where the proposed route of the canal proper commences, for 30 miles by way of the Malatengo, the valley of the Chichihua and Tarifa Rivers, to the natural summit of Tarifa Pass, the rise is 530 feet, requiring at most 53 locks. From the summit, 20 miles, down to the

lagoons, the fall is 660 feet, requiring not to exceed 63, in all 130 locks. This number may be considerably reduced by cutting down the summit. For instance, if it should be thought advisable to cut down the summit 60 feet, it would make a saving of 12 locks, in which case the total number of locks would be reduced to 118—59 on the Atlantic and the same number on the Pacific slope.

The most difficult portion of the canal to be built is embraced between the Malatengo and the foot of the mountains on the Pacific plains, and is only about 35 miles long.

In the construction of a great work like this, the health of the climate is of the utmost importance. The route upon which the heaviest work is to be done, extends mostly through a piney woods region, everywhere noted to be healthy. In fact, history for three hundred years has demonstrated that Tehuantepec is much more healthy than any other Isthmian route.

For more full information as to the health of the climate, I refer you to General Barnard's Report of 1852, pages 162 and 173.

The Isthmus belongs, in its greatest part, to the State of Oaxaca, which has a population of 600,000, and the rest to the State of Vera Cruz, which has 300,000, and is bounded on the east by the State of Chiapas, which has 200,000. In these three States alone, from 8,000 to 10,000 good and hardy acclimated laborers, who are superior in strength and morality to the Chinese, can be had for less than 50 cents per day of 12 hours, and they board themselves; and besides from these sources, labor, to any extent that can be utilized, may be had from other parts of Mexico.

This great enterprise itself would then give work to thousands of the sons of that Republic, who are now without employment, and therefore restless.

According to your plan, the dimensions of the canal are assumed to be sufficiently large to allow ships drawing 18 feet of water to pass safely, but where ships of a greater draught arrive at either terminus to go through the canal, a part of their cargo can be taken out and run across by railroad and restored on the other side of the Isthmus. Thus the railway will not only be of great use in the construction of the canal, but will forever be a valuable auxiliary.

The use of the lagoons as a harbor would probably save a breakwater and reduce the cost of the proposed railroad over the route to Salina Cruz, say one million dollars, or enough to open Boca Barra, or the canal across Tilema, as may be thought best, and make the lagoons a good harbor.

The Tehuantepec Ship Canal, above all others, is the one in which the United States is the most directly interested. It debouches into the Gulf of Mexico, our own Mediterranean, and, it may almost be said, right at our very doors

It is alleged by reliable statisticians, that the United States alone loses 35,000,000 dollars every year for the want of it—thus giving a principal of nearly six hundred millions of dollars, one-half of which, at least, our government could afford to expend in its construction.

It is only necessary to look at a map of the world to be convinced of the immense relative advantages in position, above all others, which a ship canal across the Isthmus of Tehuantepec would offer to the commerce of the world, and more especially to that of the United States.

By this route the products of the valley of the Mississippi may be shipped from the gulf ports direct for China, Japan, west coast of North and South America, and the islands of the Pacific, and the imports from these countries may be brought home to the ports of Texas, New Orleans, Mobile, Pensacola, and from thence transhipped to Memphis, Cairo, St. Louis, Louisville and Cincinnati, and be distributed throughout the Southern and Western States, even to the frontier of British America, at one-third the cost of transportation of the same

articles by the Pacific Railroad. In a word, the completion of the ship canal across Tehuantepec, will not only open a direct outlet from the Gulf of Mexico and the Atlantic to India and China, but also from the Mississippi River and tributaries, whereby the sea going vessels plying upon those waters will be able to proceed with safety to any port on the Pacific. Thus giving to St. Louis, the Queen city of the West, and the whole valley of the Mississippi, direct water communication with the Pacific side of North, Central, and South America. In a word, the completion of the Tehuantepec Ship Canal would be the opening of the mouth of the Mississippi River into the Pacific Ocean —another world of waters.

The following statement, condensed from official tables, shows the saving to the trade of the world, in insurance on vessels and cargoes, profits on time saved, interest on cargoes, saving of wear and tear of ships, saving of wages, provisions &c., by using the Tehuantepec Canal.

United States	$35,995,930.00
England	9,950,348.00
France	2,183,930.00
Other countries	1,400,000.00
Total yearly saving	$49,530,208.00

If the trade increases annually ten per cent., or one hundred per cent. in the next decade, the saving to the world will then be double the above amount.

As the annual increase of the trade of Great Britain, France, and the United States, is, together, more than ten per cent., the saving to the maritime powers of the world of $49,530,208.00 in one year, at the end of ten years will be $99,060,416.* Assuming the trade only of the three powers to increase in the same proportion, the aggregate total amount saved, at the end of ten years, will be over seven hundred millions of dollars.

Suppose the average tonnage of ships to be 1,000 tons each, then, as per the tables in this report, 3,049 ships would be requisite to carry the freight which would now annually seek the Isthmus route. Abert, estimating for Darien or Panama, makes the annual saving for each ship $15,420.00, giving as the aggregate saved upon the tonnage which would pass the Isthmus the sum of $47,709,480; and the saving of one year, at the end of ten years, would be $95,418,960, sums sufficiently near the first to establish their correctness.

Again, by a comparison of time and money, in the passage of a 1,000 ton ship from New York to California via Cape Horn, with what it would be by way of Tehuantepec, it is estimated† that the saving on the ship and cargo would be 13,300 dollars, or 13.30 dollars per ton, against a toll not to exceed 2.50 per ton. Allowing the ship to make but four trips per annum, of 45 days each, via the canal, it would give a yearly saving of 53,200 dollars. Deducting 10,000 dollars, the toll on the four trips, there results a net annual saving on a single one thousand tons ship, of 43,200 dollars.

Whale ships and coasting vessels have been estimated generally at forty dollars per ton. The United States and European commerce around the capes, is conducted in first-class ships, which often cost eighty dollars per ton. Fifty dollars has therefore been taken as a fair average value, in the construction of these tables, which do not include coasting trade nor the trade of any of the powers of the world, except England, France, and the United States.

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* See Report of S. J. Abert, C. E., entitled "Is a ship canal practicable?"

† Vide "Engineering," London, Vol. V., first half yearly.

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The following tables show the trade of the United States, England and France, which would probably pass through the Isthmus Canal if now finished, taken from the official returns of 1857 and 1858.

TRADE OF THE UNITED STATES which must pass through the canal.

Countries traded with.	Tonnage.	Exports and Imports.
Alaska	5,735	$126,537
Dutch East Indies	16,589	904,550
British Australia and N. Zealand	52,105	4,728,083
British East Indies	177,121	11,744,151
French East Indies	3,665	98,432
Half of Mexico	34,673	9,601,063
Half of New Granada	131,708	5,375,354
Central America	36,599	425,081
Chili	63,749	6,645,634
Peru	193,131	716,679
Ecuador	1,979	48,979
Sandwich Islands	33,876	1,157,849
China	123,578	12,752,062
Other Ports in Asia and Pacific	4,549	80,143
Whale Fisheries	116,730	10,796,090
California to East United States	861,698	35,000,000
Value of cargoes		100,294,687
Total tonnage	1,857,485	
Value of ships at $50 per ton		92,874,250
Total value of ships and cargoes		$193,168,937

TRADE OF FRANCE which would pass through the canal.

Countries traded with.	Tonnage.	Exports and Imports.
Chili	25,688	$10,000,000
Peru	35,096	13,160,000
Half of Mexico	10,004	2,790,000
Half of New Granada	2,389	1,090,000
Ecuador	1,650	440,000
Bolivia	1,000	100,000
California	8,997	2,073,859
China (Outward only.)	2,028	2,180,000
Dutch East Indies (Outward only.)	20,400	4,440,000
Sandwich Islands	4,119	2,000,000
Phillipine Islands	1,463	1,000,000
Australia	50,000	19,800,000
Value of cargoes		59,073,859
Total tonnage	162,735	
Value of ships at $50 per ton		8,136,750
Total value of ships and cargoes		$67,210,609

TRADE OF ENGLAND which would pass through the Canal.

Countries traded with.	Tonnage.	Exports and Imports.
Half of Mexico	11,833	$2,775,137
Half of Central America	5,615	1,244,817
Half of New Granada	10,188	2,437,605
Chili	118,311	15,486,110
Peru	244,319	20,473,520
Ecuador	1,820	360,015
China, Java, Singapore } Outward only	68,530	7,077,390
	16,003	3,821,410
	16,500	4,364,070
Australia	522,426	78,246,095
Sandwich Islands	1,950	520,560
California	11,800	2,378,105
Value of cargoes		139,184,834
Total tonnage	1,029,295	
Value of ships at $50 per ton		51,464,750
Total value of ships and cargoes		$190,649,584

The value of the tonnage which would take the Tehuantepec route is, according to the above tables:

United States	$92,874,250
England	51,464,750
France	8,136,750
	$152,475,750

TOTAL VALUE OF EXPORTS AND IMPORTS taking the same route is:

United States	$193,168,937.00
England	190,649,584.00
France	67,210,609.00
Total value of trade of the three powers passing the Isthmus	$451,029,132.00

ESTIMATED TONNAGE to pass through the canal:

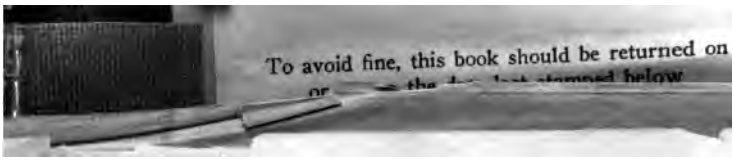
United States	1,857,485
England	1,029,295
France	162,735
Total tonnage	3,049,515

Upon the above tonnage, the yearly income, at $2 per ton, would be $6,099,030.00, which is the estimated annual gross receipts from tolls upon ships belonging to the United States, England and France.

This calculation does not include the United States coasting trade on both oceans, nor the trade that might be expected from the other nations of the world not mentioned.

The amount of $2,500 toll, now charged on a ship of 1,000 tons, on the Suez Canal, would increase the above estimated yearly income on Tehuantepec, to $7,625,000.00. This amount based upon the yearly ten per cent. increase would double itself in ten years.

In 1860, the maritime movement between *Europe alone* and the East, by way of the Cape of Good Hope, amounted to 7,250,000 tons. The ascertained rate of progress would give for 1870 a total of 11,000,000 tons; one-half of which, at least, would pass through the Suez Canal, and possibly a fifth by way of the American Isthmus.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Taking these facts into consideration, and bearing in mind that none of the trade of the Western Hemisphere is included in the 11,000,000 tons, it remains for commercial men to say whether or not we are correct in estimating an annual amount of 3,000,000 tons as likely to pass through the American Isthmus.

I have the honor to be, very respectfully,
your obedient servant,

J. J. WILLIAMS,
Chief Engineer Tehuantepec Railway Co.

TABLE A.

Showing the Length, Height of Lockage in Feet, and Number of Locks of some of the principal Canals in the World.

NAMES OF CANALS.	LOCATION.	CHARACTERISTICS.	Length in Miles.	Height of Lockage in Feet.	No. of Locks.
Chesapeake and Ohio	United States	Has 33 miles feeders, 4 miles tunnel	307	3129	398
Delaware and Hudson	United States	Canal and slack water	109	1073	110
Du Midi	France	Forty nine miles feeders	150	829	100
Burgundy	France	Deficient of water	141	1535	191
Rhone to Rhine	France	St. Jean de Losne to near Strasbourg	203	1208	164
Nantes to Brest	France	Between the Loire and Brest	218	1711	238
London to Liverpool	England	Connecting the Paddington and Grand Junction	265	1439	185
Liverpool and Leeds	England	Has 5 locks, with 17½ feet lift each	127	901	
Caledonia	Scotland	Dimensions: top, 122; bottom, 50; depth, 20	25	188	28
Tehuantepec (proposed)	Mexico	Connecting Gulf of Mexico with Pacific Ocean. Dimensions same as Caledonia	50	1184	120

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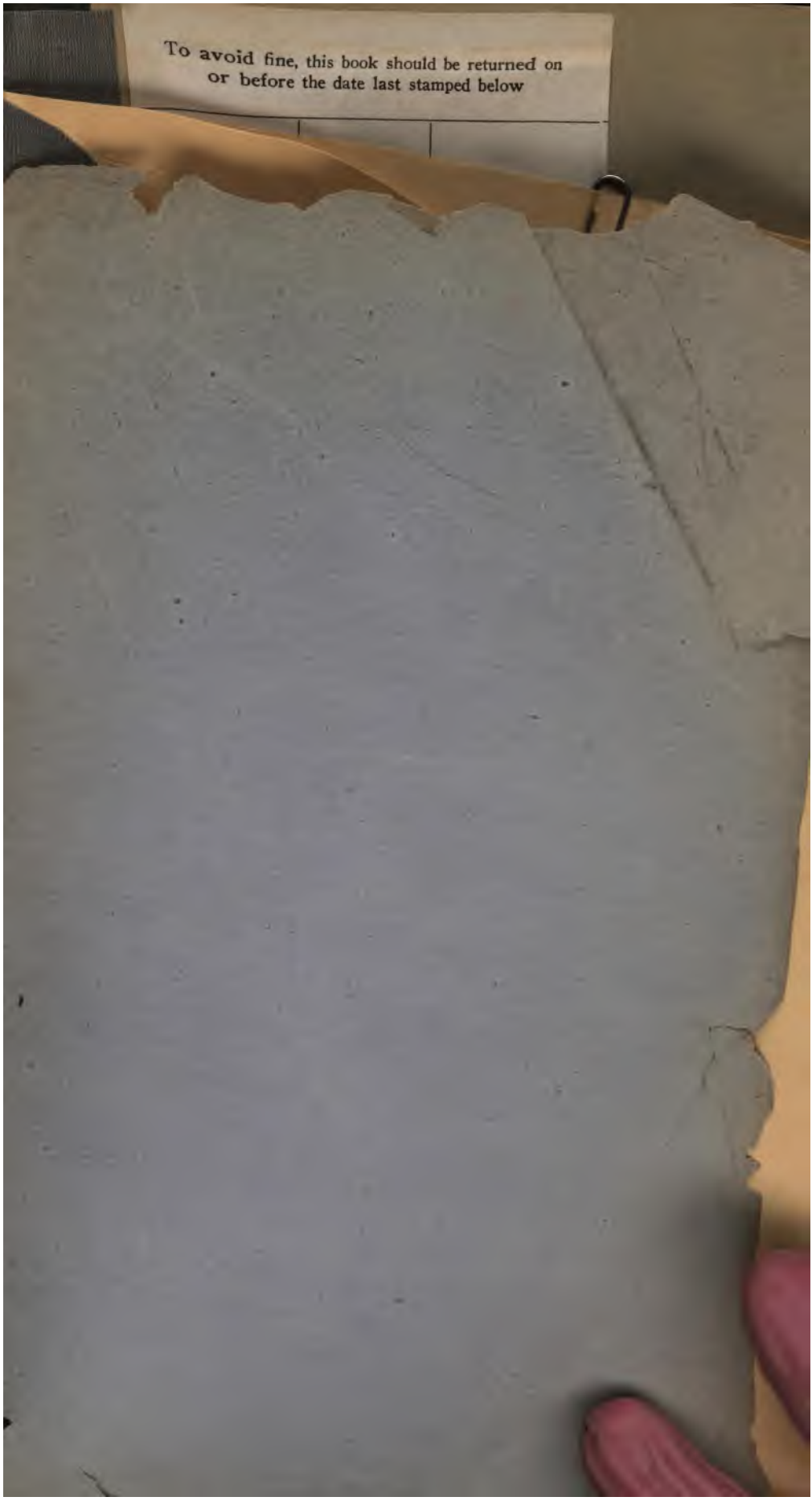

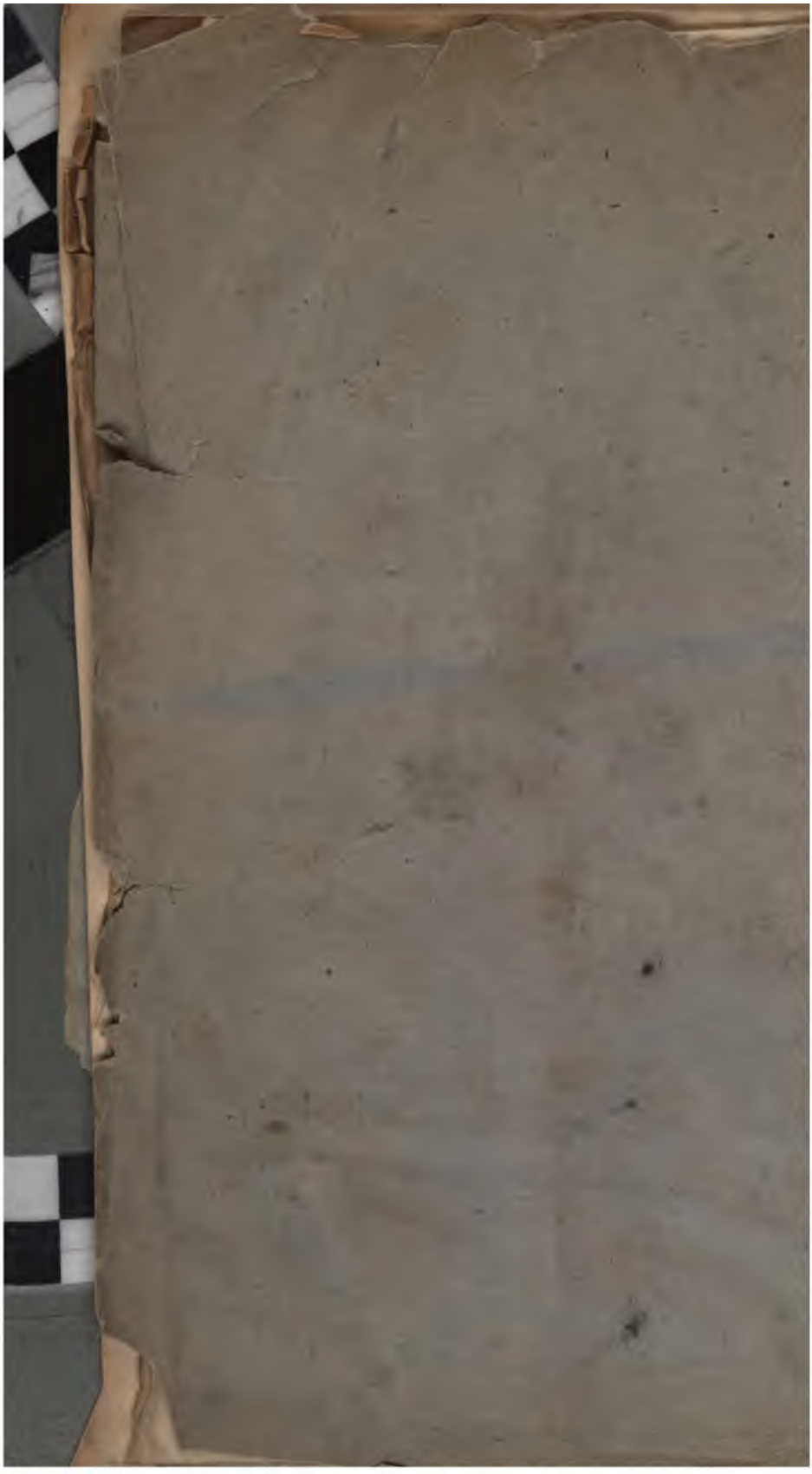

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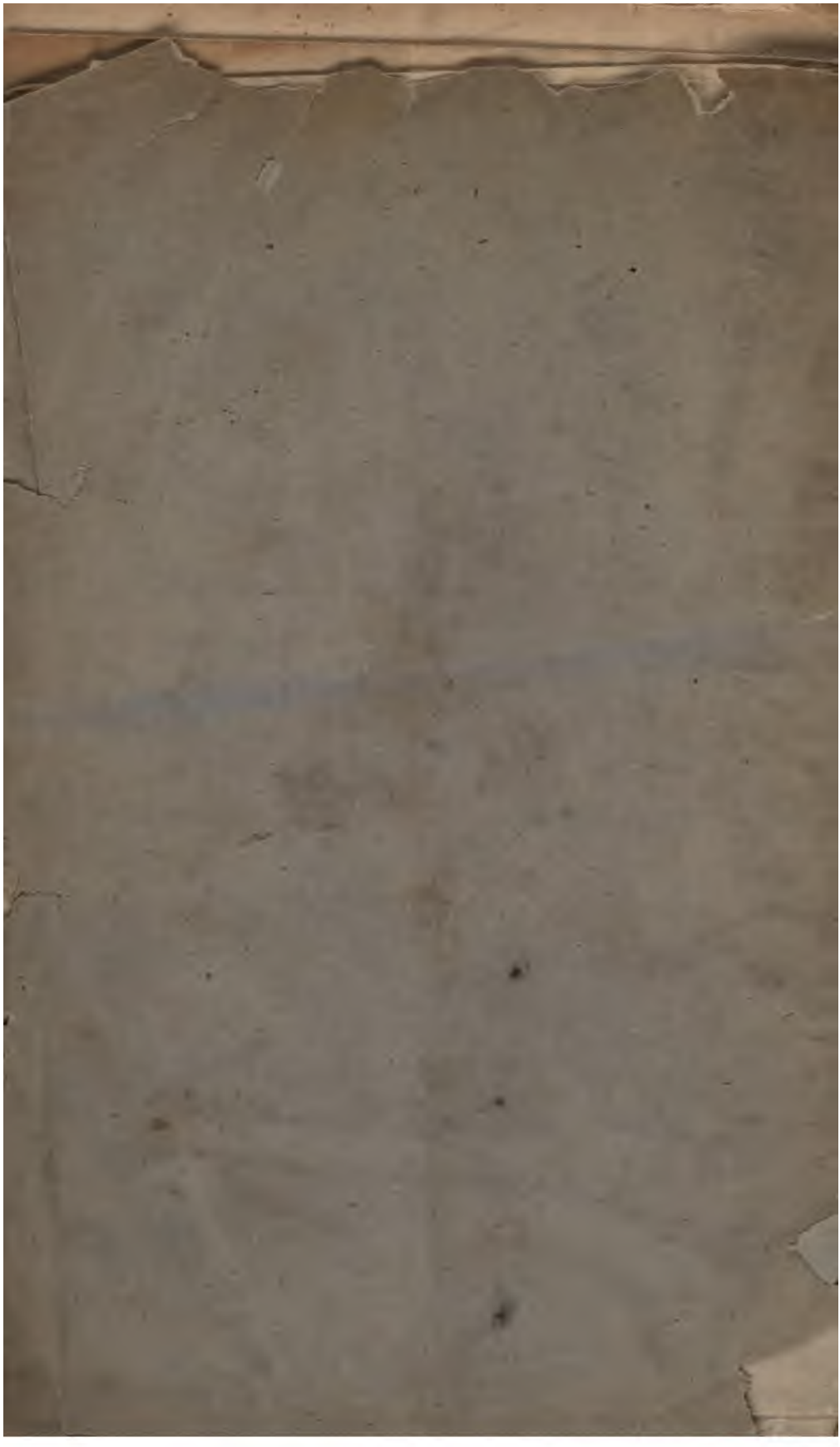

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